CLAIMS

I claim:

1. An agile positioner means responsive to an actual position of a resonant load and operative to provide drive control information for driving an actuator means to position said resonant load, comprising:

(a) adaptive resonant positioner means for generating an actual position signal, for receiving and storing desired resonant position information defining a pattern of desired resonant positions to be sequentially occupied by said resonant load at a one or a plurality of resonant instants, for outputting a resonant drive signal for positioning said resonant load at the one or the plurality of resonant instants related to a resonant frequency and for receiving an actuator drive signal for driving the actuator means;

(b) electronic data storage means for receiving and storing desired correction position information defining one or a plurality of correction positions between the desired resonant positions, to be sequentially occupied by said resonant load at one or a plurality of correction instants, for outputting current desired correction position information defining a current correction position to be occupied by the resonant load, for outputting open loop sequences operative in a current pattern, for receiving and storing modified open loop sequences attributable to the current pattern defining a set of modified drives for use in a subsequent pattern and for outputting stored modified open loop sequences attributable to a previous pattern defining a set of output drives for sequentially moving said resonant load to occupy the correction positions at the correction instants;

(c) drive means for amplifying the stored modified open loop sequences attributable to the previous pattern to produce a correction drive signal on an output line;

(d) open loop sequence computation means responsive to the current correction position and to the actual position signal for determining differences between desired and actual positions of said resonant load at the one or the plurality of correction instants in between pairs of the one or the plurality of resonant instants, and correction calculating means responsive to said differences and to the open loop sequences operative in the current pattern for calculating the modified open loop sequences attributable to the current pattern and storing the modified open loop sequences in the storage means, whereby the modified sequences are available for use in a subsequent pattern in causing said actuator means to reposition said resonant load to stop closer to successive ones of the desired correction positions; and

(e) adder means for adding said resonant drive signal to said correction drive signal to produce

the actuator drive signal on an output line.

2. The Agile positioner means as recited in claim 1 wherein the resonant drive signal is at a constant drive whereby the correction drive signal is supplied directly to the actuator means.

3. The Agile positioner means as recited in claim 1 wherein the one or the plurality of desired correction positions between the desired resonant positions, to be sequentially occupied by said resonant load at the one or the plurality of correction instants is a single correction position between the desired resonant positions, to be sequentially occupied by said resonant load at a single correction instant.

4. The Agile positioner means as recited in claim 3 wherein the open loop sequences comprise three substantially equal pulses alternating in polarity, of substantially equal width, occupying one half of a resonant period of the resonant frequency and inverting for opposite correction polarity.

5. An agile positioner means responsive to an actual position of a substantially non-resonant load and operative to provide drive control information for driving an actuator means to position said load, comprising:

(a) sensing means responsive to a substantially stationary load for generating an actual position signal;

(b) open loop sequence computation means responsive to a desired position and the actual position signal for determining differences between desired and actual positions of said load at one or a plurality of positioner cycles for each said desired position, correction calculation means responsive to said differences for calculating and outputting open loop sequences computed for a boundary state of velocity and position error at an end of the positioner cycle whereby said load moves closer to said desired position and with substantially zero velocity at the end of each positioner cycle; and

(c) drive means for amplifying the open loop sequences to produce an actuator drive signal on an output line.

6. The Agile positioner means as recited in claim 5 wherein the actuator means is linearly moveable.

7. The Agile positioner means as recited in claim 5 wherein said sensing means comprises an

analog sensor.

8. The Agile positioner means as recited in claim 5 wherein the open loop sequence comprises two substantially equal pulses opposite in polarity, of substantially equal width and inverting for opposite correction polarity.

9. The Agile positioner means as recited in claim 5 wherein the open loop sequences comprise two substantially equal pulses opposite in polarity, of substantially constant amplitude, of substantially equal width, occupying a variable width positioner cycle and inverting for opposite correction polarity, whereby the open loop sequences constitute pulse width modulation.

10. The agile positioner means as recited in claim 5 wherein said open loop sequence computation means and said correction calculation means further include a term for a velocity, whereby the positioner is responsive to the velocity of the actuator.

11. The agile positioner means as recited in claim 10 wherein the positioner cycle occupies a constant time interval.

12. The agile positioner means as recited in claim 10 wherein said sensing means includes a digital sensor means for sensing the actual position of an optical element and for responsively providing interpolated actual position signals, comprising:

(a) lighting means for emitting and focusing a beam of emitted light towards said optical element so that the beam is reflected as a beam of reflected light;

(b) optical detector means including an array of discrete photodetector elements for detecting an intensity distribution of reflected light in said array and responsively producing detection signals serially forming an intensity sample waveform output from the detector means;

(c) filter means for reducing high frequency content and forming a filtered waveform from said intensity sample waveform for improved interpolation;

(d) a threshold logic means for receiving said filtered waveform, comparing said filtered waveform to a reference threshold level, responsively producing a first and second binary envelop waveform representing an interval to a first and a second crossing of the threshold level by the filtered waveform; and

(e) a counting and averaging means for counting to a value representing a center between the first and the second crossing of the threshold level of the first and the second binary envelope waveform and outputting said total value as said interpolated actual position

signal.

13. The agile positioner means as recited in claim 12 wherein said lighting means continuously projects said beam of emitted light.

14. The agile positioner means as recited in claim 12 wherein said lighting means pulses said beam of emitted light.

15. An agile positioner means responsive to an actual position of a load and operative to provide drive control information for driving an actuator means to position said load, comprising:

(a) sensing means responsive to a substantially stationary load for generating an actual position signal;

(b) electronic data storage means for receiving and storing desired position information defining a pattern of desired positions to be sequentially occupied by said load, for outputting current desired position information defining a current position to be occupied by the load, for outputting adaptive open loop sequences operative in one or a plurality of adaptive positioner cycles in the current position of a current pattern, for receiving and storing modified adaptive open loop sequences attributable to adaptive positioner cycles within the current position of the current pattern defining a set of modified drives for use in a subsequent pattern and for outputting previously stored adaptive open loop sequences attributable to adaptive positioner cycles within the current position of a previous pattern defining a set of output drives for sequentially moving said load to occupy the desired positions;

(c) open loop sequence computation means responsive to the current position and the actual position signal for determining differences between desired and actual positions of said load at one or a plurality of positioner cycles within each said desired position to be sequentially occupied by said load, and correction calculation means responsive in a non-adaptive positioner cycle to said differences for calculating and outputting a non-adaptive open loop sequence computed for a boundary state of velocity and position error at an end of the positioner cycle and responsive in the adaptive positioner cycle to said differences and to the adaptive open loop sequence operative in the one or the plurality of adaptive positioner cycles in the current position of the current pattern for modifying the adaptive open loop sequence and storing in said storage means the modified adaptive open loop sequence whereby each positioner cycle of the current position is either adaptive or non-adaptive and results in either said non-adaptive open loop sequence or modification of the stored adaptive open loop sequence and the stored adaptive open loop sequence is available for use in a subsequent

pattern in causing said actuator means to reposition said load to move closer to successive ones of said desired positions; and

(d) drive means for selecting the non-adaptive open loop sequence in the non-adaptive positioner cycle as a selected open loop sequence, for selecting a stored adaptive open loop sequence attributable to a previous pattern in the adaptive positioner cycle as the selected open loop sequence and for amplifying the selected open loop sequence information to produce an actuator drive signal on an output line.

16. The agile positioner means as recited in claim 15 wherein said actuator means comprises a galvanometric actuator.

17. The agile positioner means as recited in claim 15 wherein the one or the plurality of position cycles within a pattern position is one position cycle.

18. The agile positioner means as recited in claim 15 wherein said sensing means includes a digital sensor means for sensing the actual position of an optical element and for responsively providing interpolated actual position signals, comprising:

(a) lighting means for emitting and focusing a beam of emitted light towards said optical element so that the beam is reflected as a beam of reflected light;

(b) optical detector means including an array of discrete photodetector elements for detecting an intensity distribution of reflected light in said array and responsively producing detection signals serially forming an intensity sample waveform output from the detector means;

(c) filter means for reducing high frequency content and forming a filtered waveform from said intensity sample waveform for improved interpolation;

(d) a threshold logic means for receiving said filtered waveform, comparing said filtered waveform to a reference threshold level, responsively producing a first and second binary envelop waveform representing an interval to a first and a second crossing of the threshold level by the filtered waveform; and

(e) a counting and averaging means for counting to a value representing a center between the first and the second crossing of the threshold level of the first and the second binary envelope waveform and outputting said total value as said interpolated actual position signal.

19. The agile positioner means as recited in claim 15 wherein said open loop sequence computation means and said correction calculation means further include a term for a velocity,

whereby the positioner is responsive to the velocity of the actuator.

20. The Agile positioner means as recited in claim 19 wherein the adaptive open loop sequence and the non-adaptive open loop sequence each comprise two substantially equal pulses opposite in polarity, of substantially equal width and inverting for opposite correction polarity.

21. A method of actuating a load means to cause said load means to stop at desired positions, comprising the steps of:

(a) receiving one or a plurality of desired positions defining desired positions at which the load means is to be stopped;

(b) defining an accurate model representing torque and motion characteristics of an actuator and the load means;

(c) selecting a set of open loop sequences of drive shapes from a group consisting of pulses and analog signals to cause the load means to predictably move and substantially stop; and

(d) performing positioner cycles of actuator open loop sequence moves to cause the load means to substantially stop at positions closer to the desired position, said step of performing positioner cycles including:

(1) sensing an actual position of said load means in response to execution of an open loop sequence of drive while said load means is substantially stopped;

(2) calculating a difference between the actual position and the desired position for said load means;

(3) computing the open loop sequence of drive to move the load means through a position change intended to equal said difference and terminate in substantially zero velocity; and

(4) executing the open loop sequence of drive independent of sensor output and thereby achieving feedback stability by position sensing while the load means is substantially stopped and driving the load means independent of position sensing.

22. The method of actuating a load means as recited in claim 21 wherein the step of receiving further comprises:

(a) inputting patterns of desired positions defining patterns of repeating positions at which the load means is to be stopped;

and wherein said step of computing further comprises:

(b) maintaining a set of open loop sequence drives for one or a plurality of adaptive positioner cycles used in executing the open loop sequence of drive through the repeating positions; and

(c) adaptively modifying the set of open loop sequence drives for the one or the plurality of the adaptive positioner cycles based on the performance of the actuator open loop sequence moves in the same positioner cycle in a current pattern of the desired positions for use in a subsequent pattern of the desired positions.